In-beam tests of PMTs and voltage dividers for particle detectors at FAIR*

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Scintillation counters are used for beam intensity, beam loss and spill structure measurements at GSI, they will be utilized at FAIR too, see [1] and the references therein. The presented study was started due to the phase out of the Photonis XP2972 photomultiplier, which is presently used in the beam diagnostic counters at GSI. Possible replacement photomultipliers (PMTs) and active voltage dividers (AVDs) were selected based on their characteristics and laboratory tests [1]. From the tested PMTs, Hamamatsu R6427 had the largest gain variation, while the ET Enterprises and the GSI in-house developed AVDs demonstrated stable operation at counting rates above 10 MHz. The response of the selected PMT and AVDs to the modulated spill structure of slowly extracted SIS beam was investigated.

Measurements and Results

The tested PMT and AVD was coupled to a 1 mm thick BC400 scintillator, in a configuration illustrated in Fig. 1 of Ref. [2]. Three scintillators were placed behind each other. The heavy ion beam penetrates the 3 mm plastic, depositing similar energy in the three detectors. The generated signals were recorded with a broad band oscilloscope, which was triggered at a programmable delay relative to the beginning of the spill extraction. A representative measurement is shown in Fig. 1, demonstrating the better performance at high counting rates of the GSI-AVD. Operating at these rates is advantageous for applications where an integrating detector, as an ionization chamber, is calibrated relatively to a scintillator counter.

The amplitude spectra shown in Fig. 2 illustrates two typical cases which can lead to inaccurate measurements: a radiation damaged scintillator and irregular spill structure. An amplitude measurement or a comparison of the counting rates above two different thresholds will provide a criteria of the measurement reliability, as shown in the inset of Fig. 2.

In conclusion, based on the tests described in this contribution and in Ref. [1], the optimum PMT-AVD combination for the future counters at FAIR and GSI is a Hamamatsu R6427 PMT powered by the GSI-AVD. In spite of the better PMT-AVD performance, a reliable measurement with the scintillation counters at instantaneous rates above 13 MHz would require amplitude information.

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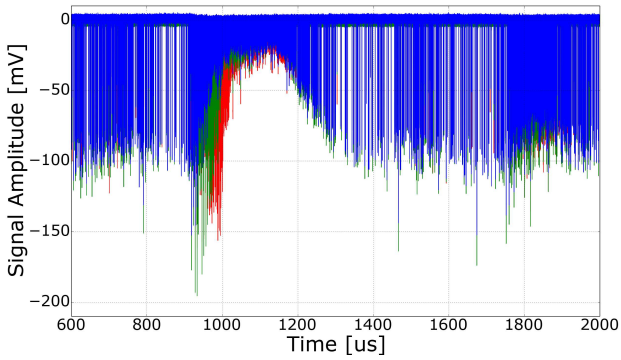

Figure 1: Pulses from ^{238}U ions at 300 MeV/u and average in spill intensity of 1 MHz. At Time$\sim$1 ms, the signal amplitude grows and falls down as the instantaneous beam intensity increases above 13 MHz. Signals from R6427 PMT powered by: GSI-AVD (in red), E220BFN2-01 (in green) and H7415MOD-AVD (in blue). The GSI-AVD withstand higher counting rates compared to the other AVDs.

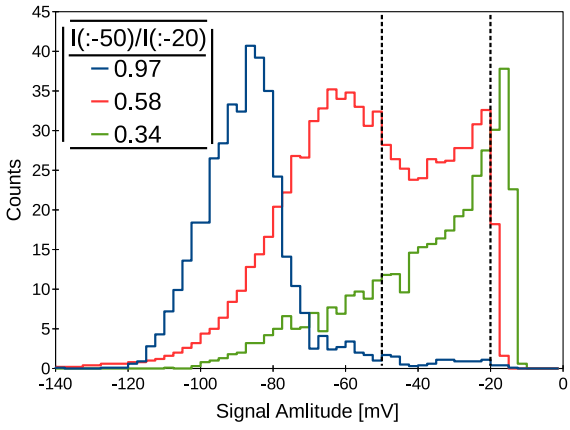

Figure 2: Signal amplitudes for normally operating PMT-AVD in blue, overloaded detector during parts of the spill in red and radiation damaged scintillator in green. The ratio of counts with amplitudes larger than 50 mV and 20 mV is shown in the inset.

References

[1] P. Boutachkov, *et al.*, "Bench Tests of PMTs and Voltage Dividers for Counting Applications at FAIR", GSI Scientific Rep. (2014)

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